REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*: 16-06-2003

2. REPORT TYPE: Technical Viewgraph Presentation

3. DATES COVERED *(From - To)*:

4. TITLE AND SUBTITLE

The Application of Fracture Mechanics to Estimate the Crack Length for Developing an Inspection Criterion

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

C.T. Liu

5d. PROJECT NUMBER
2302

5e. TASK NUMBER
0378

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRSM
10 East Saturn Blvd.
Edwards AFB CA 93524-7680

8. PERFORMING ORGANIZATION REPORT NUMBER

AFRL-PR-ED-VG-2003-160

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S NUMBER(S)
AFRL-PR-ED-VG-2003-160

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

For presentation at the ASME Pressure Vessel Conference in Cleveland, OH, 21-25 July 2003.

14. ABSTRACT

20030812 148

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Leilani Richardson
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	A	17	(661) 275-5015

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. 239.18

The Application of Fracture Mechanics to Estimate the Crack Length for Developing an Inspection Criterion

C. T. Liu

AFRL/PRSM

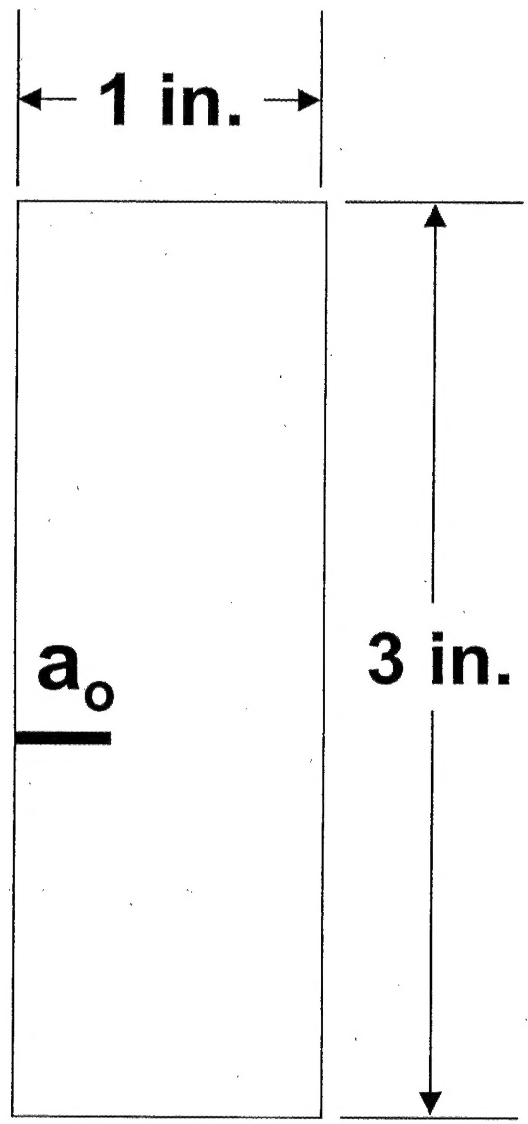
Edwards AFB, CA

Objectives:

- Determine the Inherent Critical Initial Crack Size in a Particulate Composite Material for Developing an Inspection Criterion.

- Determine the Statistical Distribution Function of the Inherent Critical Crack Size.

Specimen Geometry



a_o = 0.0 in.
= 0.1 in.
= 0.2 in.
= 0.3 in.

Crack Growth Equations

$$K_I = \sigma\,(\pi\, a)^{1/2}\, f\,(a/w)$$

$$f\,(a/w) = 0.7722(a/w)^3 + 0.9253(a/w)^2 + 1.095(a/w) + 1.005$$

$$K_{IC} = \sigma_c\,(\pi a_c)^{1/2}\, f\,(a_c/w)$$

$$da/dt = Q\, K_I^{\,m}$$

Statistical Distribution Functions

$F_X\ (\mathrm{x}) = \Phi\ (\frac{\mathrm{x}-\mathrm{u}}{\sigma})$ **Normal Distribution**

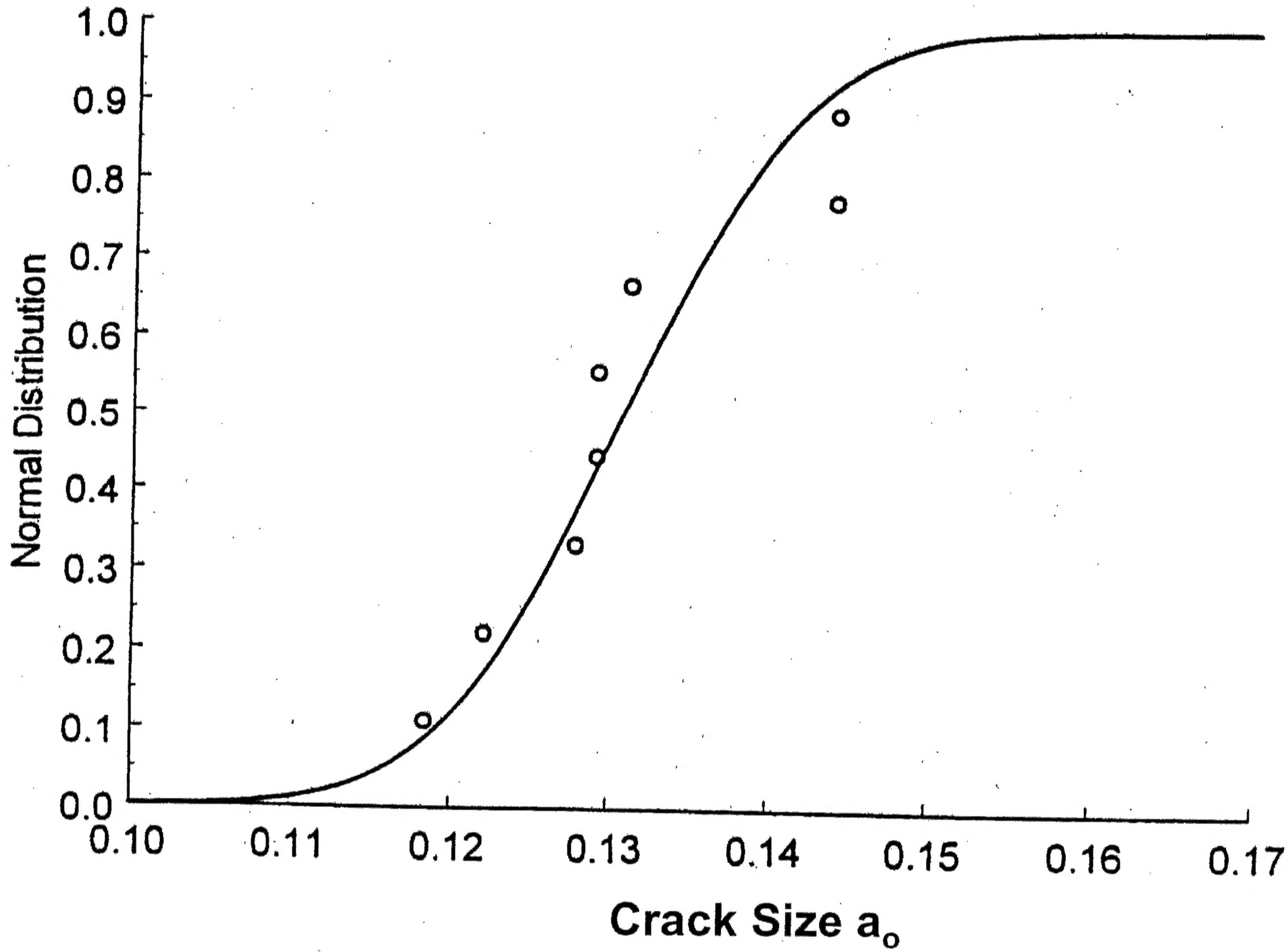
$F_X\ (\mathrm{x}) = \Phi\ (\frac{\ln \mathrm{x}-\mathrm{u}^*}{\sigma^*})$ **Lognormal Distribution**

$F_X\ (\mathrm{x}) = 1 - \exp\ [(x/\beta)^\alpha\ ]$ **Two-Parameter Weibull Distribution**

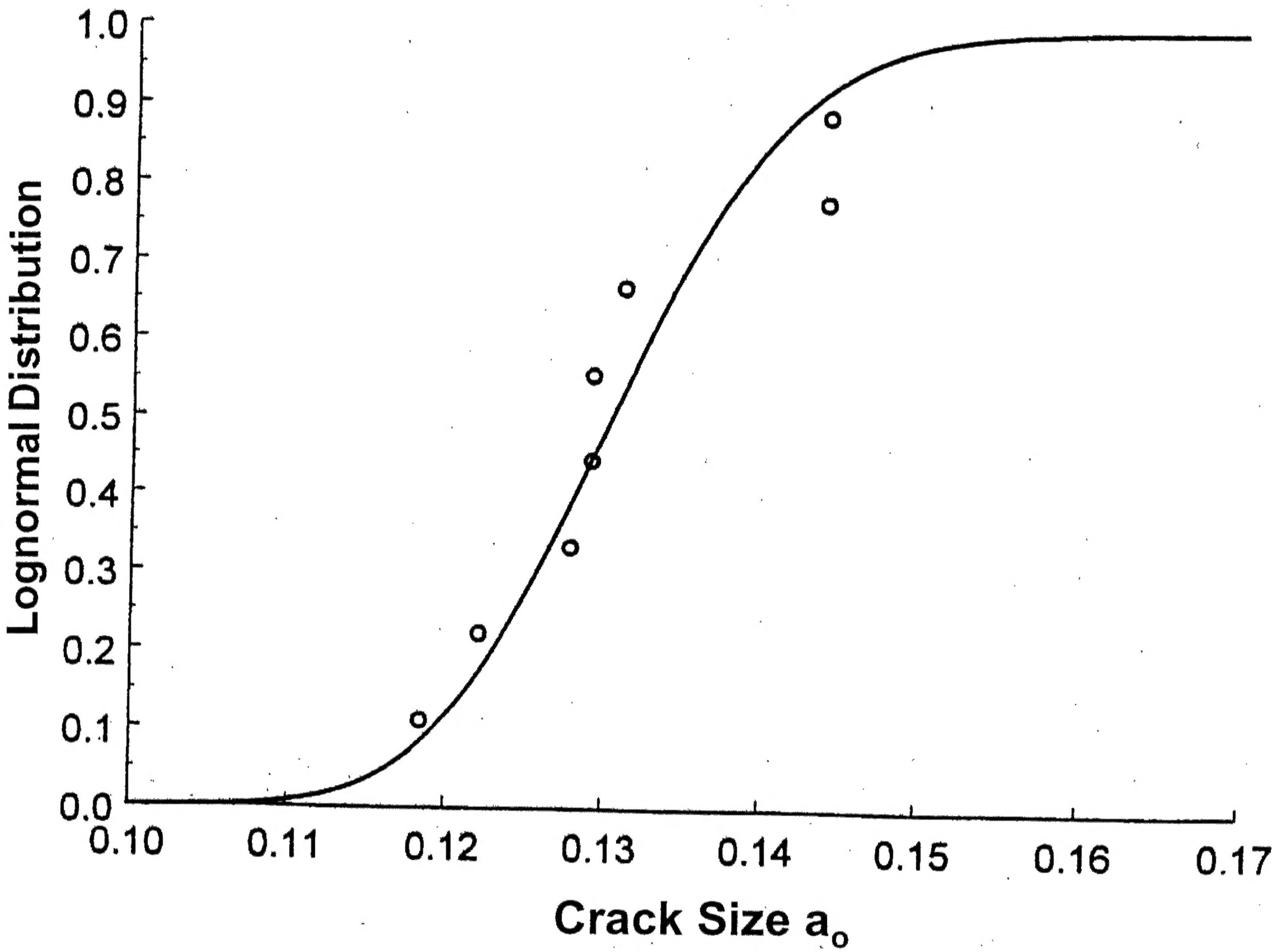
$F_X\ (\mathrm{x}) = \exp\ [-\ (x/\nu)^{-\kappa}\ ]$ **Second Asymptotic Distribution of Maximum value**

$F_X^*\ (\mathrm{x}) = 1 - F_X\ (\mathrm{x})$ **Exceedance Curve.**

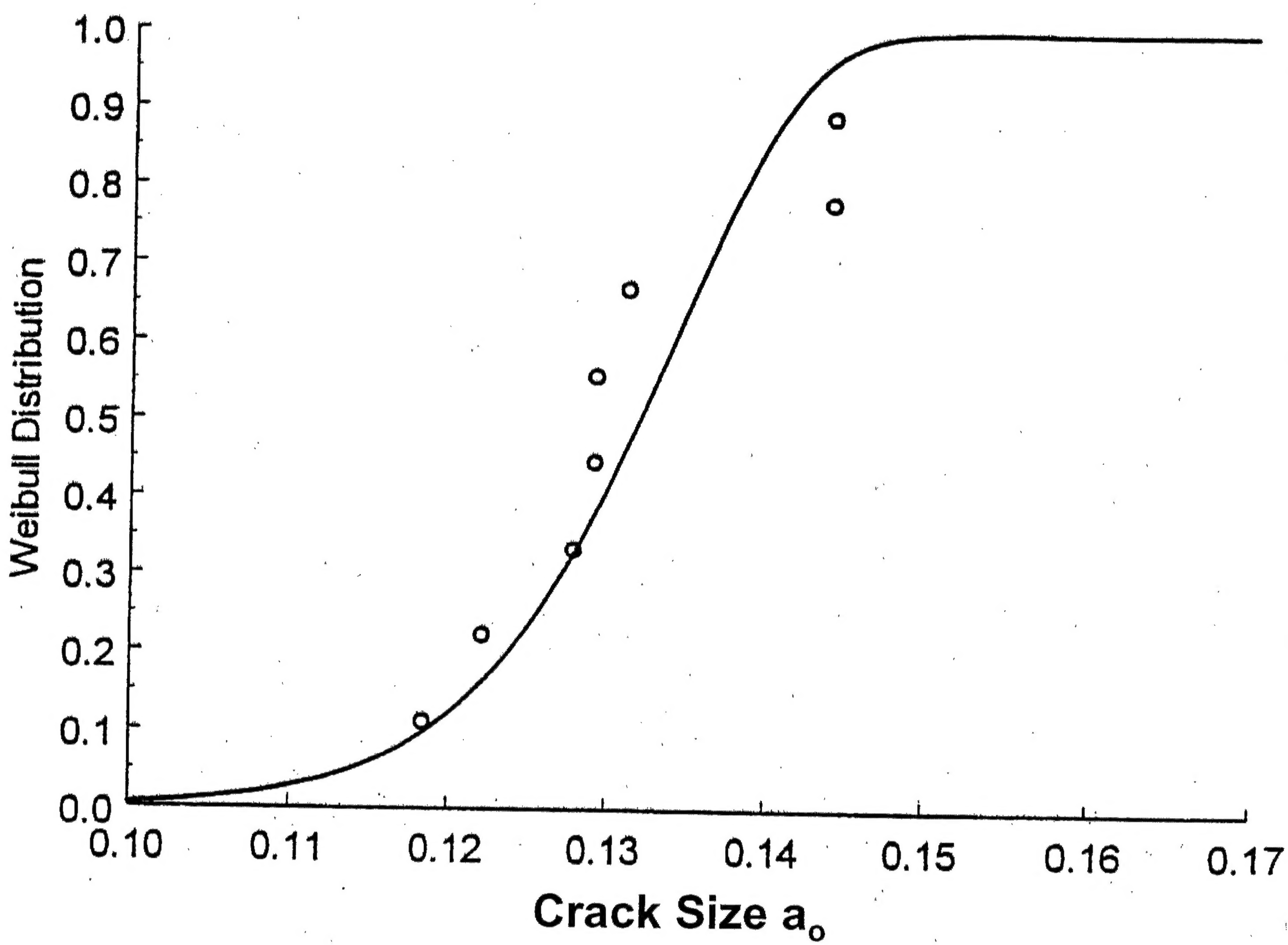
Normal Distribution Plot for a_o



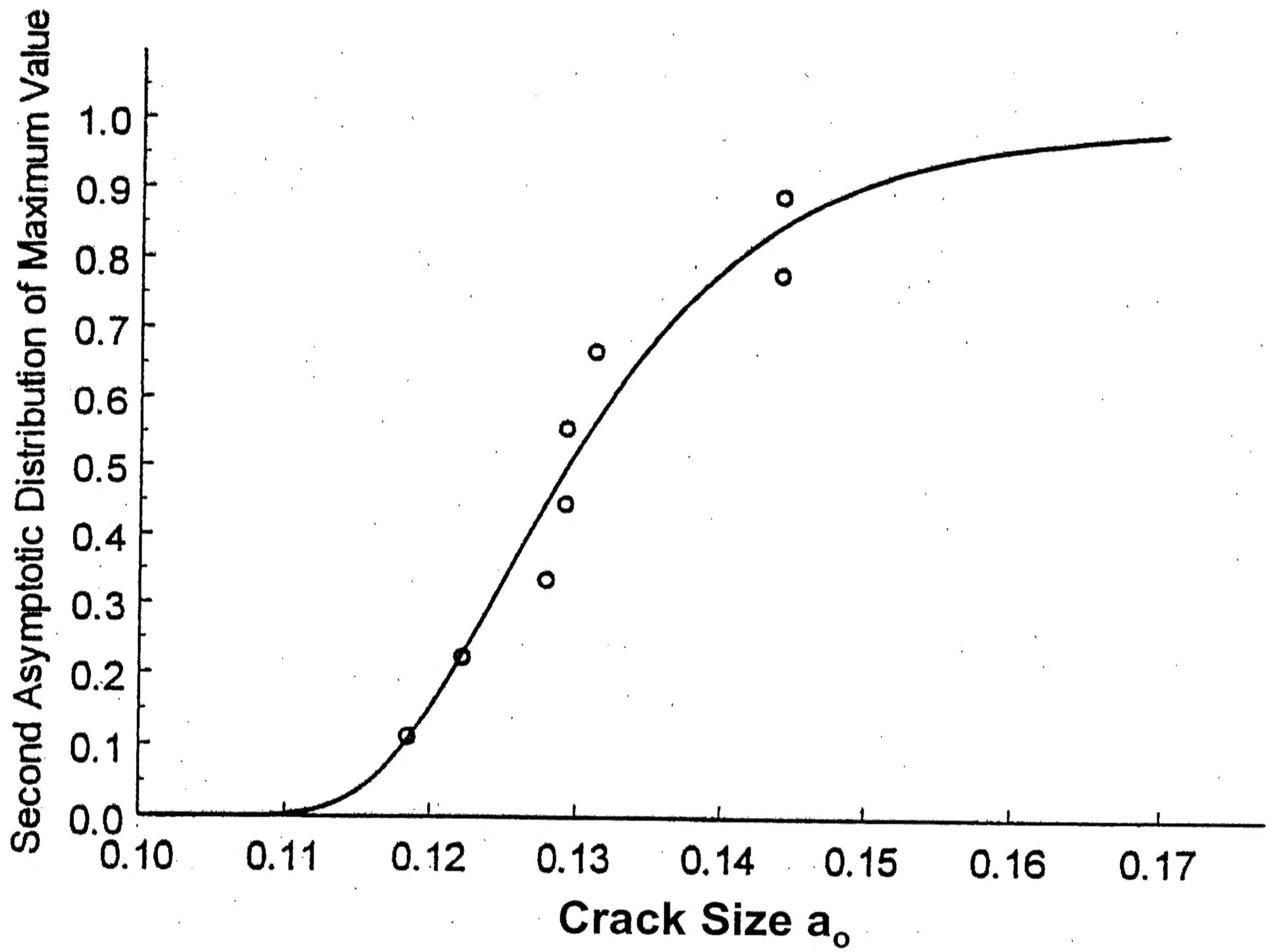
Lognormal Distribution Plot for a_o



Weibull Distribution Plot for a_o



Second Asymptotic Distribution Plot for a_o



Distribution Parameters for Normal, Lognormal, Weibull and Asymptotic Distributions

Strain Rate = 0.04 min^{-1}

	a_0	a^*	a_c
u	0.1308	0.1344	0.1462
σ	0.0092	0.0090	0.0079
u^*	-2.037	-2.0092	-1.9242
σ^*	0.07021	0.06692	0.053961
α	17.5546	18.4513	23.0450
β	0.1348	0.1383	0.1497
k	13.2524	13.8081	17.1205
υ	0.1258	0.1295	0.1419

Liu 9June2003.ppt

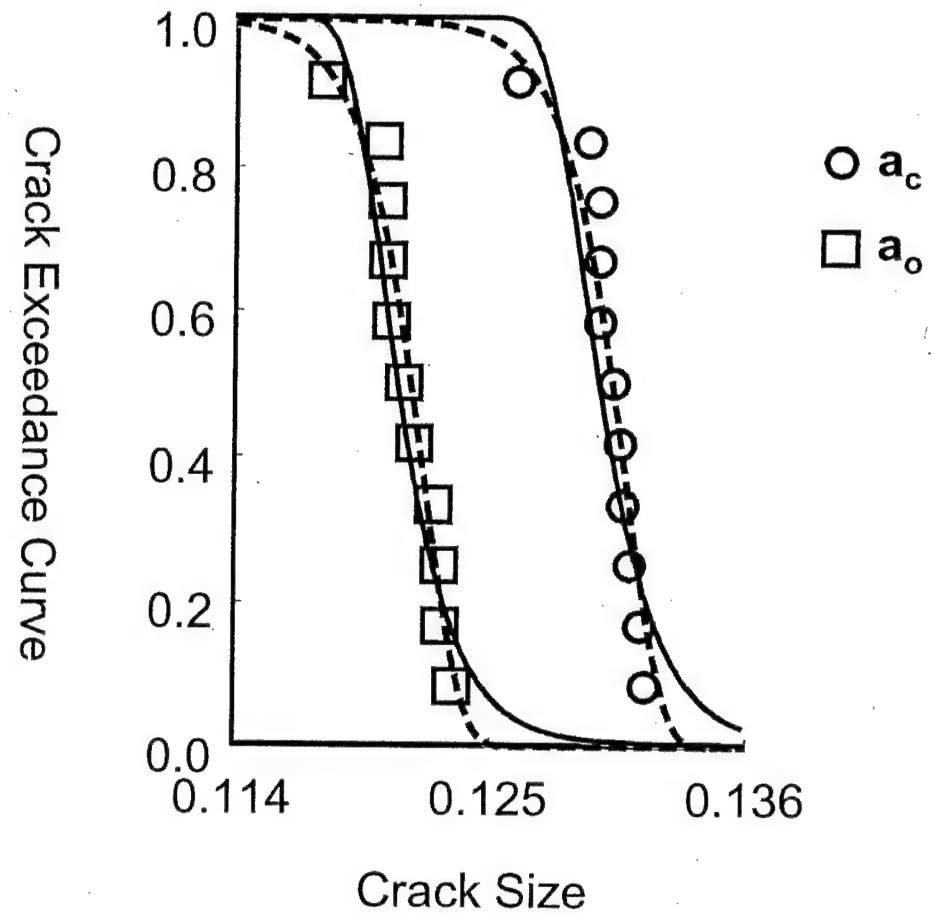
Distribution Parameters for Normal, Lognormal, Weibull , and Asymptotic Distributions

Strain Rate = 0.727 $min.^{-1}$			
Parameters	a_c	a^*	a_o
μ	0.12999	0.12131	0.11865
σ	0.00152	0.00159	0.00157
μ^*	-2.04037	-2.10951	-2.13163
σ^*	0.01172	0.01315	0.01324
α	80.1416	74.4660	74.4279
β	0.1308	0.1221	0.1194
κ	72.4100	70.8130	71.9883
ν	0.1291	0.1204	0.1178

Distribution Parameters for Normal, Lognormal, Weibull , and Asymptotic Distributions

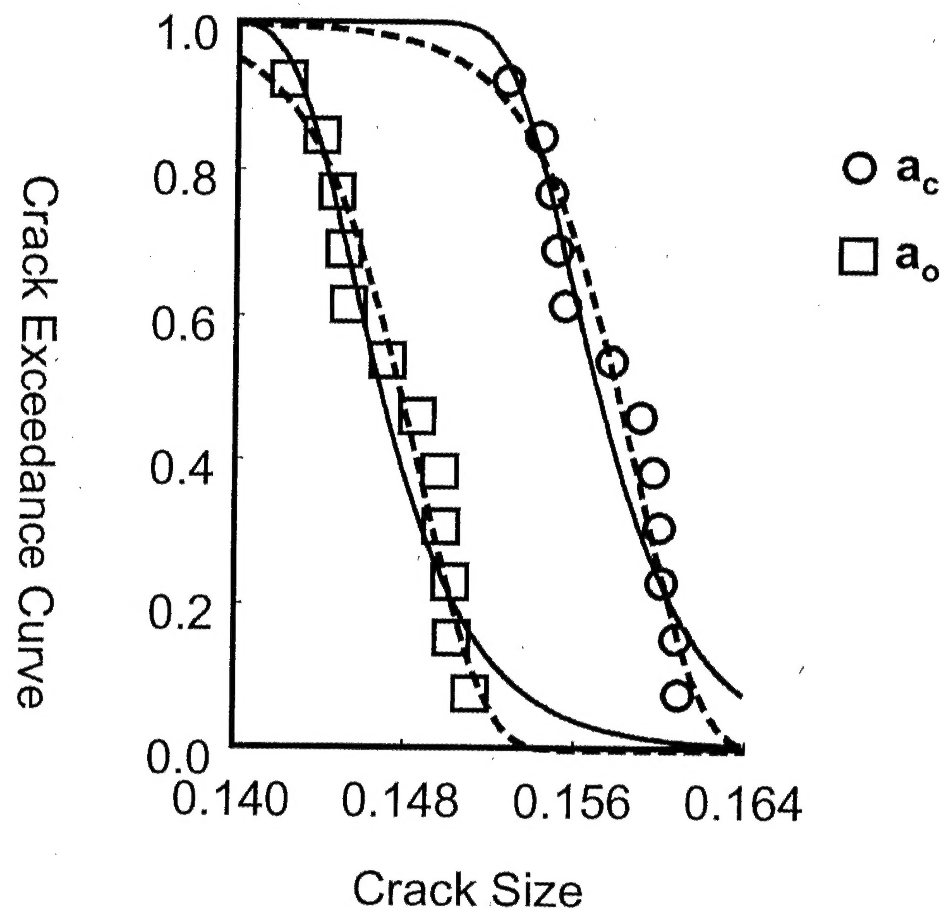
Strain Rate = 18.182 min.$^{-1}$			
Parameters	a_c	a^*	a_o
μ	0.15750	0.14735	0.14597
σ	0.00290	0.00296	0.00290
μ^*	-1.84847	-1.91517	-1.92456
σ^*	0.01842	0.02008	0.01989
α	53.6601	49.5994	50.0668
β	0.1590	0.1488	0.1474
κ	51.3708	47.7906	48.4144
ν	0.1559	0.1458	0.1444

Crack Exceedance Curves for Strain Rate = 0.727 min^{-1}



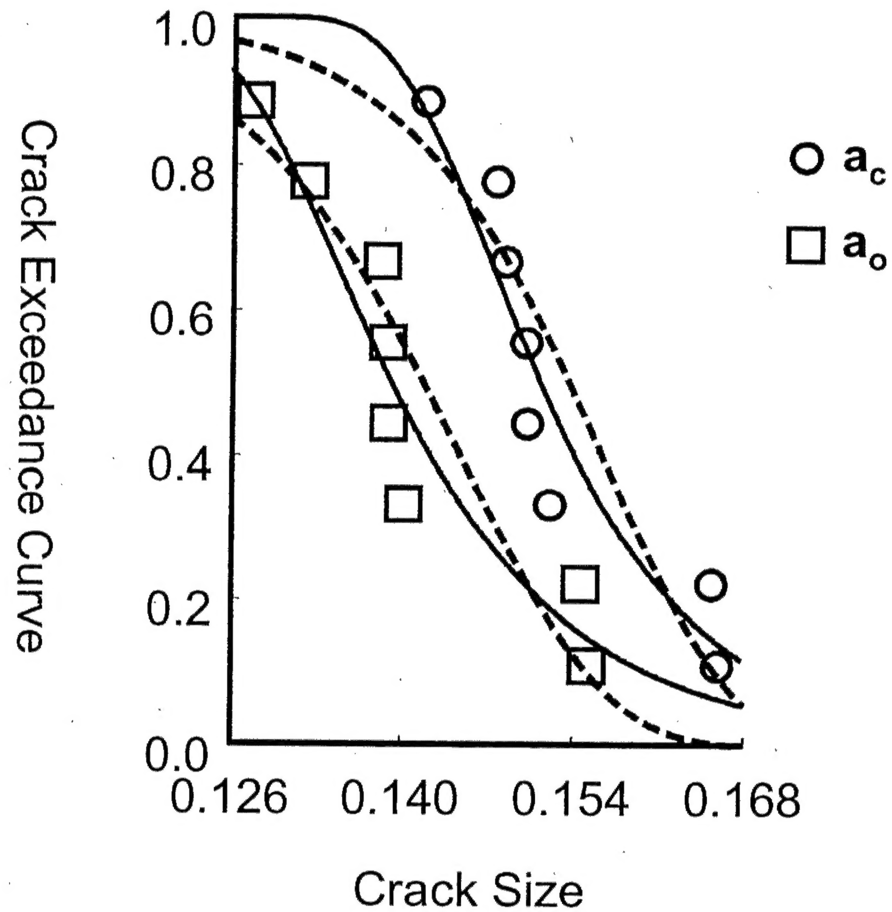
Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

Crack Exceedance Curves for Strain Rate = 18.182 min.$^{-1}$

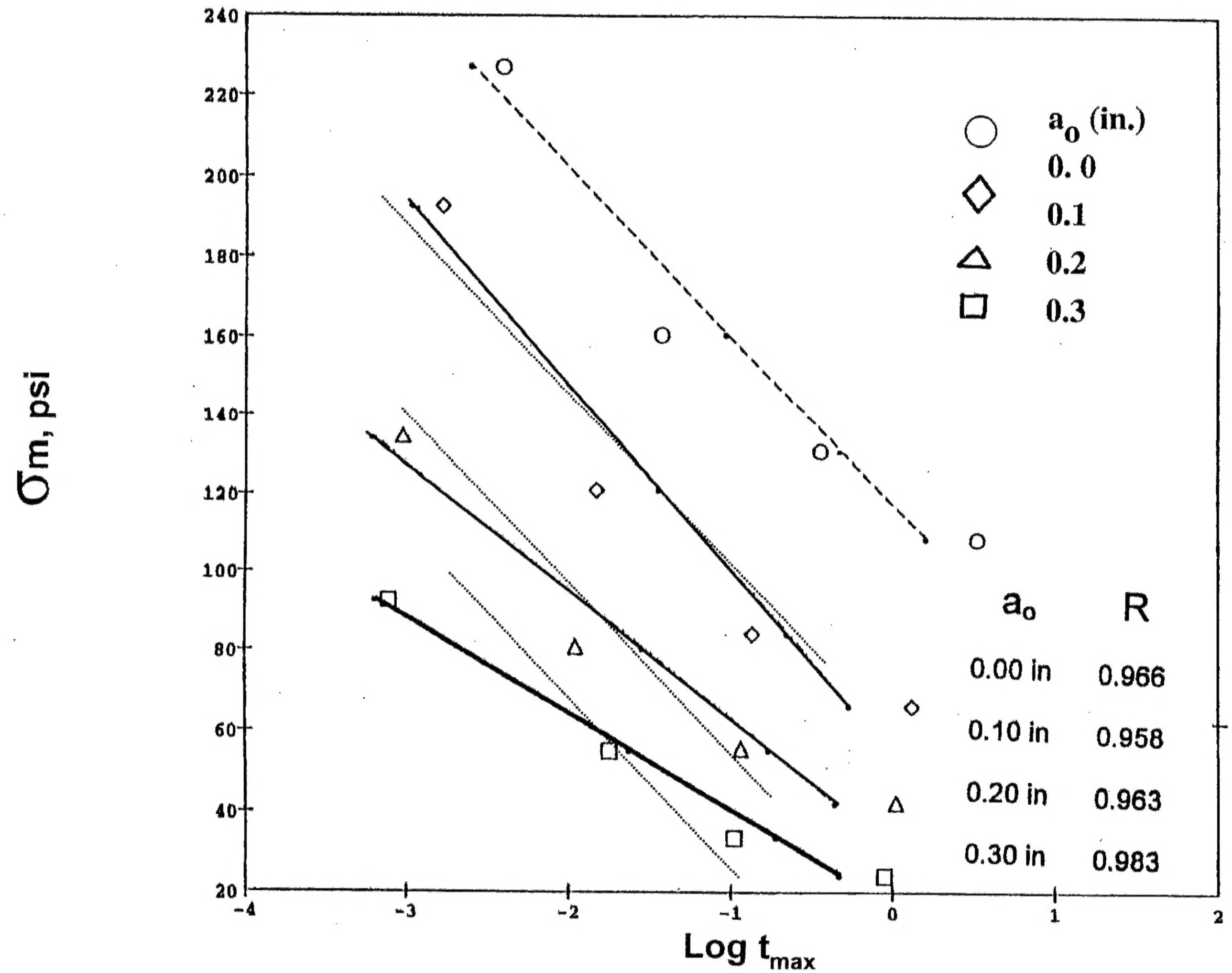


Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.

Crack Exceedance Curves for Strain Rate = 0.04min.$^{-1}$



Solid Curves for Second Asymptotic Distribution and Dashed Curves for Weibull Distribution.



Maximum Stress Vs Maximum Time

Conclusions:

- For the material studied, the estimate inherent critical crack size, a_o, is insensitive to the strain rate and the averaged value of a_o is 0.132 in., which compares well with experimental value.

- The inherent critical crack size follows the second asymptotic distribution of the maximum value.

- The estimated a_o should be used to develop the inspection criterion.